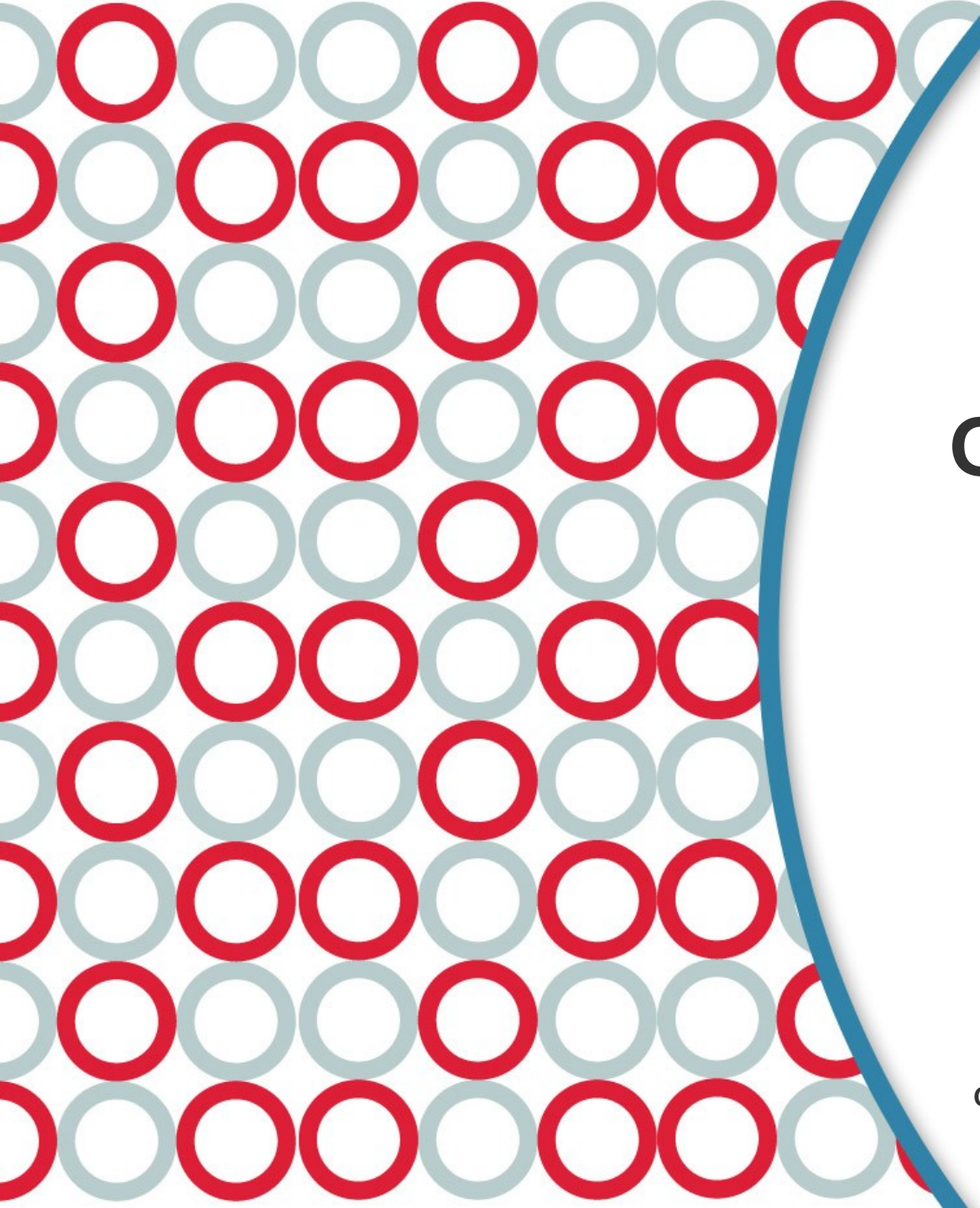

April 2022, IPT Course
Java Web Debelopment

Generics and Collections

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About me

Trayan Iliev

– CEO of IPT – Intellectual Products & Technologies

– Oracle® certified programmer 15+ Y

– end-to-end reactive fullstack apps with Java, ES6/7, TypeScript, Angular, React and Vue.js

– 12+ years IT trainer

– Voxxed Days, jPrime, jProfessionals, BGOUG, BGJUG, DEV.BG speaker

– Organizer RoboLearn hackathons and IoT enthusiast (http://robolearn.org)

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Where to Find the Code?

Java Web Development projects and examples are available @ GitHub:

https://github.com/iproduct/java-fundamentals-2022

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Agenda for This Session

- toString(), hashCode(), and equals()
- Collections Overview,
- Collection interfaces,
- Sorted collections, comparators
- Using Collections
- Generic Types

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Arrays. Comapring and Sorting

- Arrays and working with them
- Utility methods of the class **Arrays**:
  - equals()
  - fill()
  - copyOf() и copyOfRange()
  - binarySearch()
  - sort()
- Comparing objects – interfaces **Comparable** and **Comparator**

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Container Classes and Interfaces. Iterators.

- Collections – interface **Collection**
- Lists – interface **List**, implementations – **ArrayList**, **LinkedList**, ...
- Set – interface **Set**, implementations – **HashSet**, **TreeSet**, …
- Dictionaries – interface **Map**, implmentations – **HashMap**, **TreeMap**, **LinkedHashMap**, **WeakHashMap**, …
- Iteration over a collection using Iterator.
- Abstract data structures stack, queue and dequeue – interfaces **Queue** and **Dequeue**. Implementations.

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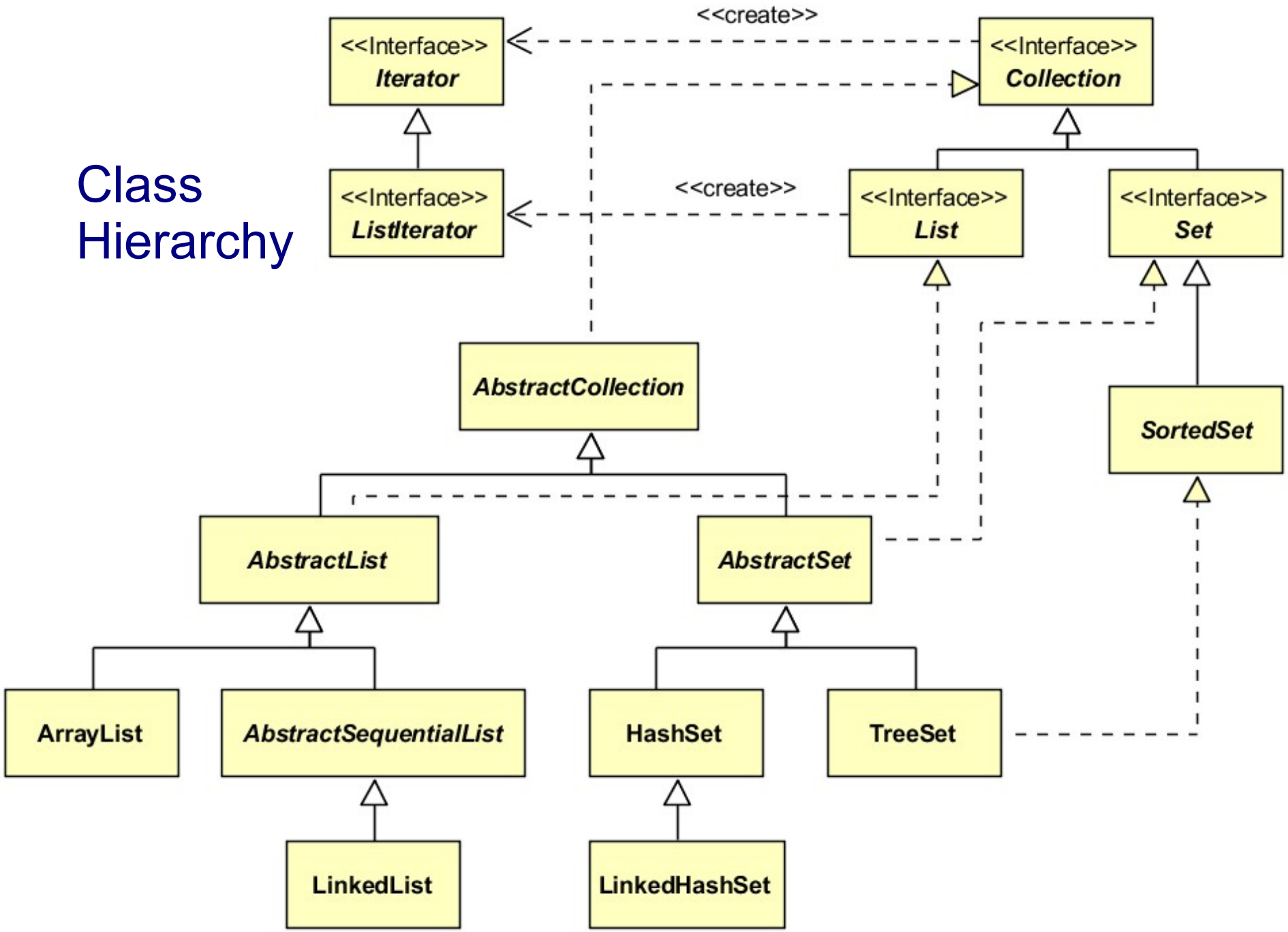
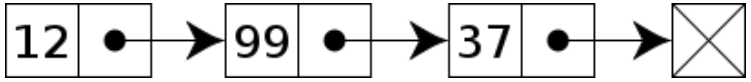
Class Hierarchy

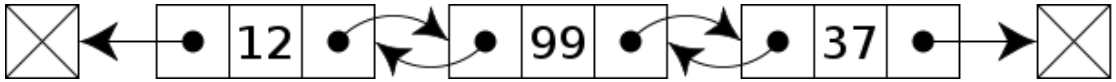


Data Structures

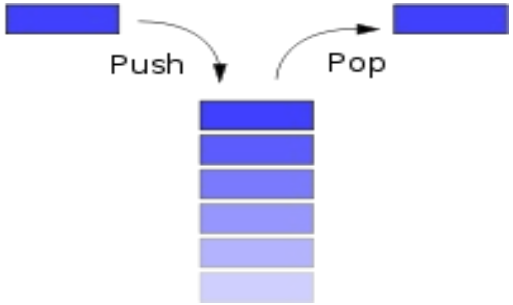
- Linked list:



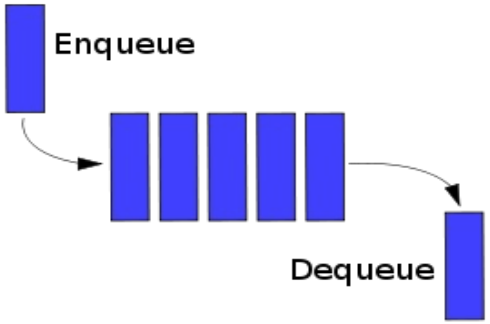
- Doubly-linked list:



- Stack:

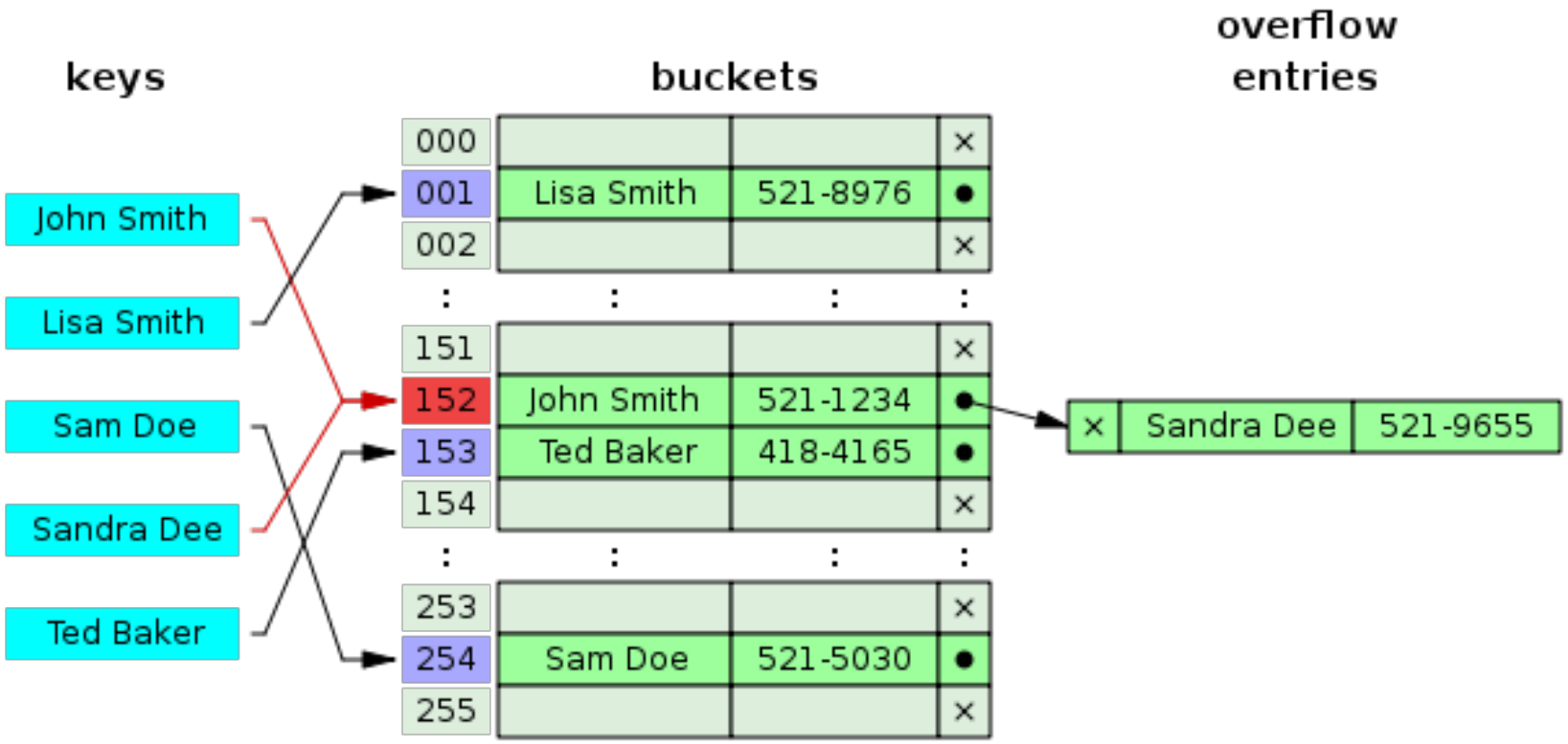


- Queue:



Source: Wikipedia, http://en.wikipedia.org/

Hashinng. Hash-Functions. Hash Tables



Source: http://en.wikipedia.org/wiki/File:Hash_table_5_0_1_1_1_1_0_LL.svg

Parameterizied Types: Generics (1)

- Collections and their methods before Java 5 were limited to handle a single type of elements.

- If we want to create typed containers we had to implement different container types for each entity type.

- *Example:* In a e-Bookstore we want to sell **Books** and want the container to contain only **Books** (being strongly typed) --> we should implement separate class **BookList**, as well as for each **Book** we want to keep a list of **Authors** --> we should implement **AuthorList** too, and so on.

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Parameterizied Types: Generics (2)

❖*Solution:* We can skip writing multiple similar classes (e.g. typed containers for each type of elements) using **Generic types**

❖*Generic type invocation:*

```
List<Book> books = new ArrayList<Book>()
List<Author> authors = new ArrayList<Author>()
```

❖**<>** – ***Diamond*** *operator* – new in Java™ 7, allows automatic inference of the generic type:

```
List<Book> books = new ArrayList<>()
List<Author> authors = new ArrayList<>()
```

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Parameterizied Types: Generics (3)

- *Generic type declaration:*

```
public class Position<T extends Product> {
        private T product;
        ...
        public Position(T product, double quantity) {
                this.product = product;
                this.quantity = quantity;
                price = product.getPrice();
        }
        public T getProduct() {
                return product;
        }
...
```

Generic data type

Conventions Naming Generic Parameters

- Generic parameters naming conventions:
  - T – type parameter (if there are more – S, U, V, W ...)
  - E – element of a collection – e.g.: List<E>
  - K – key in associative pair – e.g.: Map<K,V>
  - V – value in associative pair – e.g.: Map<K,V>
  - N – number value
- *Example:*

```
public class Invoice <T extends Product> {
        ...
        private List<Position<T>> positions = new ArrayList<>();
    ...
}
```

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Generic Methods (1)

- We can implement generic methods and constructors too:

```
public static <U extends Product> String
getPositionsAsString (List<Position<U>> positions) {
    StringBuilder posStr = new StringBuilder();
    int n = 0;
    for(Position<U> p: positions){
        posStr.append( String.format(
"\n| %1$3s | %2$30s | %3$6s | %4$4s | %5$6s |%6$8s |",
++n, p.getProduct().getName(), p.getQuantity(),
p.getProduct().getMeasure(),p.getPrice(), p.getTotal()
        ));
    }
    return posStr.toString();
} ...
```

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Generic Methods (2)

- Invoking generic method / constructor:

```
result += Invoice.<T>
getPositionsAsString(positions);
```

- OR we can let Java to automatically infer the generic type:

```
result += Invoice.getPositionsAsString(positions);
```

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Bounded Type Parameters

❖We can define upper bound constraint for the possible types that can be allowed as actual generic type parameters of the class / method /constructor:

```
public static <U extends Product> String
getPositionsAsString (List<Position<U>> positions) { ... }
```

❖OR

```
public static <U extends Product & Printable> String
getPositionsAsString (List<Position<U>> positions) {
    ...
    p.getProduct().print();
    ...
}
```

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Generics Sub-typing

- If the class Product extends class Item, can we say that List<Product> extends List<Item> too? Can we substitute the first with the second?
- The answer is „**NOT**“, because the basic generic type is not designed to reflect the specifics of of the Products.
- Dos and donts when using generics inheritance:

```
interface Service extends Item; Service s = new Service( ...);
Collection<Service> services =  ...; services.add(s); // OK
interface Product extends Item; Product p = new Product( ...);
Collection<Product> products =  ...; products.add(p); // OK
Collection<Item> items = ...; items.add(s); items.add(p); // OK
items = products; // NOT OK
items = services; // NOT OK
```

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Using ? as Type Specifier (Wildcards)

❖If we want to declare that we expect specific, but not pre-determined type, which for example extends the class **Item**, we could use **?** To designate this:

```
Collection<? extends Item> items; // Upper bound is Item
items = products; // OK
items = services; // OK
Items.add(p); // NOT OK – Can not write into it – it is not safe!
Items.add(s); // NOT OK – Can not write into it – it is not safe!
for(Item i: items) { // OK – Can read it – it is known to be at least Item.
    System.out.println( i.getName() + „:“ + i.getPrice() );
}
List<? super Product> products; // Lower bound is Product
products.add(p); // OK – Can write into it – it is now safe.
Product p = products.get(0); //NOT OK may be superclass of Product
```

❖Producer extends and Consumer super (PECS) principle

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Type Erasure & Reification

•**Type Erasure** – chosen in java as backward-compatibility alternative – information about generic type parameters is erased during compilation, and is NOT available in runtime – the generic type becomes compiled to its basic raw type:

Collection<Product> products; --(runtime)--> Collection products;

This design decision creates problems if we want to create generic type instance with **new**, or to convert to the generic type, or to check the generic type using **instanceof**.

•**Reification** – better alternative strategy, implemented in languages such as C++, Ada и Eiffel, using which the generic type information is accessible in runtime.

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Generic Containers

- Allow compile time type checking – earlier error detection
- Remove unnecessary typecasting to more specific types – less ClassCastExceptions
- Examples:

```
Collection <String> s = new ArrayList <String>();
Map <Integer, String> table = new HashMap <Integer, String>()
```

- New for loop – for each element of a Collection :

```
for(String i: s) { System.out.println(i) }
```

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Main Implementing Classes. Examples

- Associative lists (dictionaries) – interface **Map**
- Comparing different implementations:
  - **HashMap**
  - **TreeMap**
  - **LinkedHashMap**
  - **WeakHashMap**
- Hashing.
- Cash implementations – **Reference, SoftReference, WeakReference и PhantomReference**
- Choosing a container implementation

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Resources

- Oracle Generics tutorial:

https://docs.oracle.com/javase/tutorial/extra/generics/index.html

Thank's for Your Attention!

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